

Ten new bathyal and abyssal species of Scaphopoda from the Atlantic Ocean

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ABSTRACT

Ten new species of Scaphopoda (one of the Order Dentaliida and nine of the Order Gadilida) from bathyal and abyssal depths in the North Atlantic Ocean, Caribbean Sea, and northern Brazil are described. The material was collected during diverse expeditions carried out by European and American research institutions. The new species are named as, in the order Dentaliida: *Laevidentalium abyplaine* new species; and in the order Gadilida: *Pulsellum filiforme* new species, *Striopulsellum sandersi* new species, *Striopulsellum knorr* new species, *Striopulsellum atlantis* new species, *Cadulus unilobatus* new species, *Gadila celtica* new species, *Gadila cretea* new species, *Chistikovia atlantica* new species and *Siphonodentalium coronatum* new species. These findings confirm that the deep-water realm, even in regions historically considered as well known, are far from being adequately inventoried.

Additional keywords: Mollusca, deep-sea, new species, geographic distribution

INTRODUCTION

The scaphopod fauna recorded from the Atlantic Ocean includes some 132 species. Ninety of them are distributed over the western areas (including the Caribbean Sea to Sub-Antarctic waters) and 42 were reported from the eastern side (including the Mediterranean Sea and West Africa). Seven species are considered to have ampho-Atlantic distribution. For the northwestern Atlantic and Caribbean, the first comprehensive revision was published by Henderson (1920). Subsequent taxonomic arrangements and some new species descriptions did not substantially modify their number. In the northeastern Atlantic region, since early discoveries, the number of species remained notably stable. More than 85% of species (36) were described during the 19th Century. The most prolific authors at the time were Jeffreys (1877,

1883) who described nine species, M. Sars (1859, 1865) and Locard (1897), who described four. More recently, Nicklès (1955, 1979) described twelve new species from western Africa, but, for the northeastern region, it was not until 1979 that a new species, *Siphonodentalium laubieri*, was described from bathyal depths of the Norwegian Sea (Bouchet and Warén, 1979). Later, Scarabino (1986 a, b) described respectively two other abyssal species: *Wemersoniella turnerac* and *Annulipulsellum cuzkadii* (both ampho-Atlantic, see Caetano et al., 2006). Those papers also include two other new species, described from the abyssal realm of the Argentinian Basin (from 5332–5781 m): *Wemersoniella duartei* and *Costentalina venae*. Detailed information on localities and type depositories of the species registered for this large region is given in Steiner and Kabat (2004).

During revision of bathyal and abyssal collections in localities of the Atlantic Ocean, a surprising number of new species (one belonging to Dentaliida and nine to Gadilida) were identified and are described here. Five of them were collected only in the North and central Atlantic basins, two have ampho-Atlantic distribution and three come from diverse localities of the western Atlantic such as the Puerto Rico Trench and northern Brazil basins. The Atlantic deep-sea records mentioned for *Chistikovia* Scarabino, 1995 and *Striopulsellum* Scarabino, 1995 genera given by Scarabino (1995: 323, 327) refers to the species here recorded. The finding of the ten new species here described confirm that the deep-water realm, even in regions historically considered as well known, are far from being adequately inventoried.

MATERIALS AND METHODS

The material was collected during oceanographic cruises carried on by European and North American institutions. The first group were mostly French and made in

the Gulf of Gascony: BIOGAS I–XII (1972–1981) and INCAL (1973); off Portugal and Spain: ABYPLAINE (1982); North Atlantic: NORATLANTE (1969); off Azores: BIAÇORES (1971) and in the Vema Trench: BIOVEMA (1977), all IFREMER/MNHN. Additional European materials came from expeditions of the R/V INGOLF (1895) (ZMUC) and R/V PRINCESSE-ALICE II (1911) (MOM). North American cruises, all WHOI, were carried out in the Puerto Rico Trench: R/V KNORR cruise 25 (1972), Blake Plateau and North American Basins: R/V KNORR cruise 35 (1973), R/V CHAIN, cruises 50 and 106 (1965, 1972); and the Pernambuco Trench: R/V ATLANTIS II cruise 31 (1967). The total represents 56 localities in depths from 1456 to 5875 m, 40 of which carried out below 4000 m depth.

For further information on the expeditions ABYPLAINE (1982); BIAÇORES (1971), BIOGAS I to XII (1972–1981), BIOVEMA (1977), INCAL (1973) and NORATLANTE (1969), see http://www.ifremer.fr/biocean/acces_fr/data_fr.htm; R/V ATLANTIS II; R/V CHAIN and R/V KNORR (WHOI) between 1967 and 1972, <http://www.whoi.edu/>; INGOLF, 1895 in: Results of the Danish Ingolf-Expedition, Copenhagen; R/V PRINCESSE-ALICE II (1911) Results of the scientific campaign of the Prince of Monaco, vol 89.

Radula: As stated in Scarabino and Scarabino (2010), the scaphopod radula is large enough to facilitate visualization of the different teeth of that convey taxonomic information. The radula is especially useful in taxa of the Order Gadilida, in which the small rachidian teeth are always covered by the laterals. The pictures shown in this article correspond to elements of medial rows; this is done to avoid illustration of used teeth and not yet fully formed (young) teeth. SEM images were processed in the Service Commun de Microscopie Électronique des Laboratoires des Sciences de la Vie (MNHN, Paris).

Shell: Shell descriptions are based on the holotypes and radula on holotypes, paratypes or selected specimens as noted in the text. Live collected specimens are indicated as (lv) and shells as (dd). Shell measurements are expressed in millimeters and include: length (L); maximum diameter (Max); distance of point of maximum diameter to anterior aperture (Dmax); diameter of oral aperture (Oap); maximum curvature (Arc); distance of point of maximum curvature from the apex (Larc); apical aperture diameter (Apd). For shells with oval cross-section, maximum and minimum values are included in Max and Oap. Maximum length of specimens other than the holotypes are indicated in the remarks.

Abbreviations: Institutional abbreviations used in the text are: AIM: Auckland Institute and Museum, Auckland; ANSP: Academy of Natural Sciences, Philadelphia; NHMUK: The Natural History Museum, London; IFREMER: Institut Français de Recherche pour l'Exploitation de la Mer, France; MCZ: Museum of Com-

parative Zoology, Harvard University; MNHN: Muséum national d'Histoire naturelle, Paris; MOM: Musée Océanographique de Monaco; QM: Queensland Museum; USNM: National Museum of Natural History, Washington, DC; WHOI: Woods Hole Oceanographic Institution, Woods Hole; SAM: South Australian Museum, Adelaide; SMHN: Naturhistoriska Riksmuseet, Stockholm; ZMB: Museum für Naturkunde, Berlin; ZMO: Zoologisk Museum, Universitetet i Oslo, Oslo; ZMUC: Zoological Museum University of Copenhagen, Copenhagen.

SYSTEMATICS

Class Scaphopoda Bronn, 1862
Order Dentaliida da Costa, 1776

Family Dentaliidae (Children, 1834)

Genus *Laevidentalium* Pilsbry and Sharp, 1897

Laevidentalium abyplaine new species
(Figures 1–5)

Description: Shell 43.3 mm long, slender, faintly curved, porcelain white, subtle longitudinal threads near apex. Sides irregularly outlined by well-defined growth lines. Cross section slightly dorsoventrally compressed in anterior 3/4, circular toward posterior aperture. Apex oblique, with ring-shape callus and lumen circular.

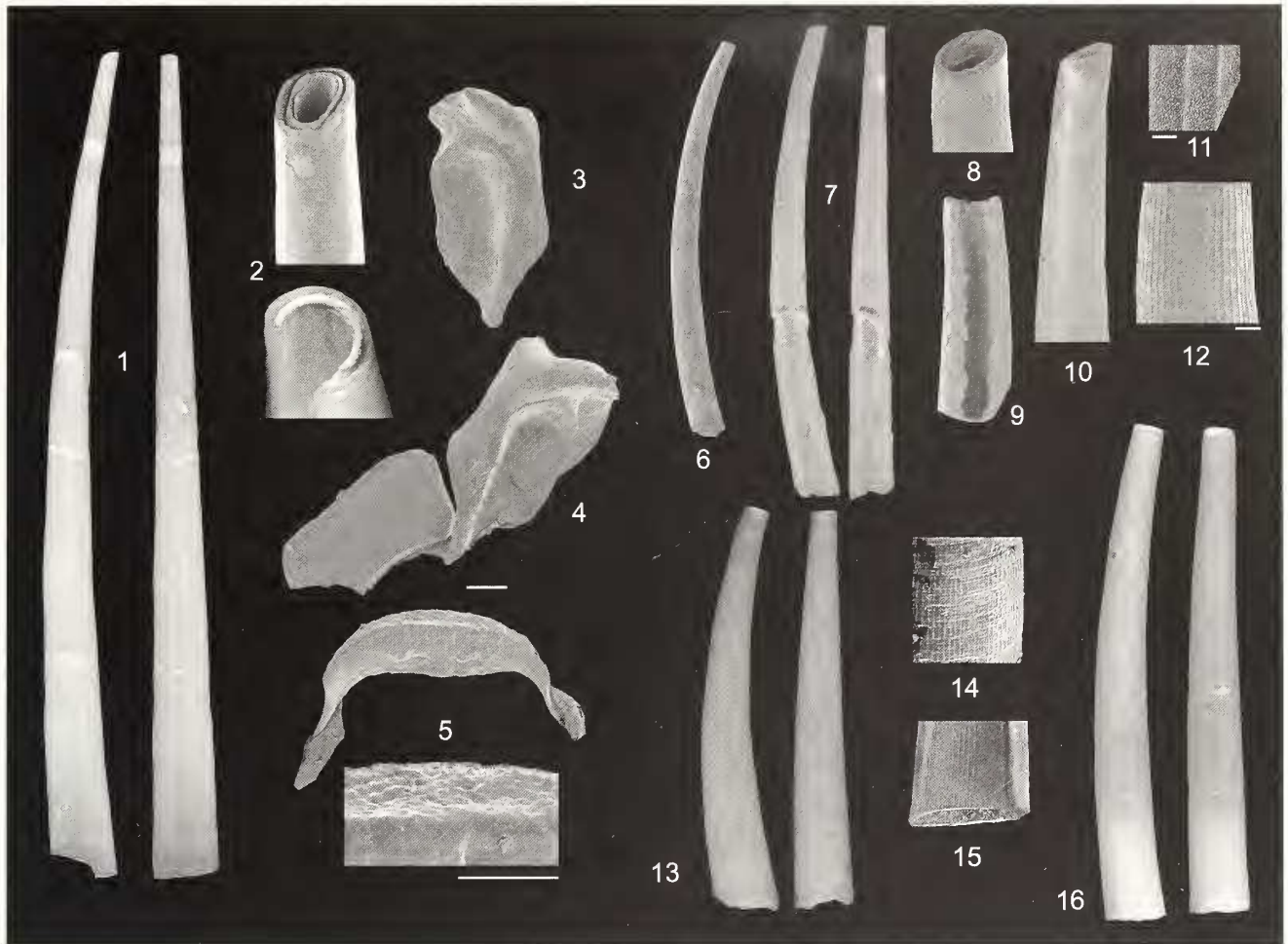
Radula (Specimen from type locality): Rachidian teeth strong, curved, with strongly granulose anterior surface; lateral teeth solid, with short but strong cusps and irregular grooves, anterior part of head smooth; marginal short almost straight.

Type Material: Holotype (lv) MNHN 24331 and 2 paratypes (lv) MNHN 24332.

Measurements of Holotype: L 43.3, Max 3.3/3.4, Apd 0.9, Arc 1.65, Larc 14.

Type Locality: Off Portugal, 39°59.5' N, 15°00.2' W–39°59.2' N, 15°02.1' W, 5330 m (ABYPLAINE stn CP 14).

Other Material Examined: ABYPLAINE, stn CP 13, 40°00.8' N, 15°05' W–39°59.2' N, 15°05' W, 5270 m, 4 dd, 1 lv; stn CP 14, 39°59.5' N, 15°00.2' W–39°59.2' N, 15°02.1' W, 5330 m, 5 lv (holotype and 2 paratypes), 12 dd; stn CP 15, 39°59.5' N, 15°00.2' W–39°59.2' N, 15°02.1' W, 5320 m, 1 dd; stn CP 19, 43°00.1' N, 15°53.1' W–42°59.1' N, 14°02.9' W, 5280 m, 10 dd; stn CP 20, 42°59.7' N, 14°07.2' W–42°58.8' N, 14°05.4' W, 5260 m, 8 dd; stn CP 21, 42°57.7' N, 13°59.2' W–42°58' N, 14°44.0' W, 5260 m, 5 dd; stn CP 23, 44°39.9' N, 17°55.9' W–44°42.8' N, 17°57.5' W, 4990 m, 3 dd; stn DS 09, 40°00' N, 15°03' W, 5320 m, 4 dd; stn DS 10, 42°51' N, 15°55' W, 4360 m, 2 dd; stn DS 11, 43°00' N, 14°05' W, 5260 m, 4 dd; stn DS 12, 44°40' N, 17°53' W, 4990 m, 7 dd; stn DS 13, 44°41.2' N, 17°49' W, 4990 m, 6 dd. BIOGAS IV, stn DS 54, 46°31' W, 10°29' W, 4659 m,



Figures 1–16. Species of *Laevidentalium*, *Pulsellum*, and *Striopulsellum*. **1–5.** *Laevidentalium abyplaine* new species. **1.** Holotype (43.3 mm), off Portugal, 39°59.5' N, 15°00.2' W–39°59.2' N, 15°02.1' W, 5330 m, ABYPLAINE stn CP14, lateral and dorsal views of shell. **2.** Details of apex, INCAL stn OS 03. **3–5.** Radula, paratype, type locality. **3.** Lateral tooth, internal view. **4.** Lateral and marginal teeth, lateral view. Scale bar = 10 μ m. **5.** Rachidian tooth, anterior border and detail. Scale bar = 100 μ m. **6.** *Pulsellum filiforme* new species, holotype (8.9 mm), Puerto Rico Trench, 8°12.4' N, 55°50.2' W, 2487–2500 m, R/V KNORR 25 stn 301, lateral view of shell. **7–12.** *Striopulsellum sandersi* new species. **7.** Holotype (7.2 mm), North Blake Plateau, 40°42.6' N, 46°13.8' W, 4400 m, R/V CHAIN 106, stn 334, lateral and dorsal views of shell. **8.** *Striopulsellum sandersi* new species, external view of apex. **9.** Section showing internal view. **10.** External view of apex and details of internal structure by transparency. **11.** Microsculpture of the surface. Scale bar = 10 μ m. **12.** Same specimen, sculpture at center of shell. Scale bar = 100 μ m. **13.** *Striopulsellum minimum* (Plate, 1908) (6.8 mm), Argentine Basin, 43°58' S, 52°09' W, 5781 m, R/V VEMA 1961, stn V-15-80, lateral and dorsal views. **14–15.** *Striopulsellum atlantis* new species, holotype (6 mm) off Pernambuco, Brazil, 7°58' S, 34°17' W, 943–1007 m, R/V ATLANTIS-II-31-167. **14.** Detail of sculpture at center of shell. **15.** Shell sculpture on oral area. **16.** *Striopulsellum knorr* new species, holotype (5.5 mm), Puerto Rico Trench, 11°2.2' N, 55°4.8' W, 4417–4429 m, R/V KNORR 25, stn 288; lateral and dorsal views.

1 dd, BIOGAS VI, stn CP 15, 46°32.2' N, 10°28.5' W, 4715 m, 1 dd; stn CP 16, 46°27.3' N, 10°25.8' W, 4825 m, 2 dd; stn CP 17, 46°30.8' N, 10°19.5' W, 4706 m, 2 lv. INCAL, stn OS 03, 46°02.5' N, 10°19.5' W, 4798 m, 10 dd; stn OS 04, 46°03.9' N, 10°12.8' W, 4796 m, 1 lv, 6 dd; stn WS 05, 46°03' N, 10°15' W, 4804 m, 1 dd; stn CP 12, 46°00.5' N, 10°18.3' W, 4796 m, 8 lv, 6 dd.

Etymology: Named (name in apposition) after the French expedition ABYPLAINE (1982) to northeastern Atlantic depths in recognition to its success on the discovery of new deep-sea species.

Distribution: Collected alive between 4796 and 5330 meters in the northeastern Atlantic Ocean off the coast of Portugal, in the Gulf of Gascony, and off northern France. *Laevidentalium abyplaine* is considered exclusively abyssal.

Remarks: Young specimens present a shallow apical notch on ventral side of apex. This feature led us to consider that the apical aspect of adult specimens is probably due to a reabsorption process. *Laevidentalium abyplaine* can be compared to *Laevidentalium leptosceles* (Watson, 1879) (Lectotype NHMUK 1887.2.9.21, examined) widely

distributed in the Indo-Pacific region in 918–5300 m depth (Scarabino, 1995). The new species is more tapering, curved and smooth, whereas *L. leptosceles* has clear longitudinal undulations, especially on the dorsal side. It also can be compared in outline to *Graptacme acutissima* (Watson, 1879) (Lectotype NHMUK 1887.2.9.31, examined) from the Indo-Pacific, but this latter has a well-defined apical notch on ventral side and longitudinal sculpture near apex. Other bathyal and abyssal Atlantic *Graptacme*, such as *Graptacme perlonga* (Dall, 1881) (Lectotype MCZ 7752, examined) is much more solid, longer, less tapering and also has apical notch and longitudinal sculpture at apex, clearly noticeable under lens. Larger specimens reach 49 mm length. *Laevidentalium abyplaine* would be the first living *Laevidentalium* recorded for the Atlantic Ocean. However, given the few conchological characters of this genus and the fact that its type species is an Eocene fossil (*Dentalium incertum* Deshayes, 1825), it is here suggested that the generic allocation of all living and fossil *Laevidentalium* should be globally reviewed.

Order Gadilida Starobogatov, 1974
Suborder Gadilomorpha Steiner, 1992
Family Pulsellidae Boss, 1982

Genus *Pulsellum* Stoliezka, 1868

Pulsellum filiforme new species (Figures 6, 30–31)

Description: Shell 8.9 mm long, thread-like outline, markedly curved, arc close to middle of shell, very slow tapering. Surface irregular, translucent with white opaque patches. Apex and mouth simple, straight, section circular.

Radula (Holotype): Rachidian teeth polygonal, sides almost parallel, and anterior margin with pointed edge. Lateral teeth wide at the base and with well-armed head bearing four denticles, the two lateral teeth longer and pointed. Marginal teeth simple, straight.

Measurements of Holotype: L 8.9, Max 0.9, Apd 0.5, Arc 0.9, Larc 4.7.

Type Material: Holotype (lv) MCZ 293968, 5 paratypes (lv) MCZ 202969, 293970–73; 1 paratype (dd) MNHN 24333.

Type Locality: Puerto Rico Trench, 8°12.4' N, 55°50.2' W, 2487–2500 m, R/V KNORR 25 stn 301 (WHOI).

Other Material Examined: R/V KNORR 25, stn 293, 08°28.8' N, 54°04.3' W, 1456–1518 m, 1 lv; stn 299, 7°55.1' N, 55°42.0' W, 1942–2076 m, 3 lv (1 paratype), 5 dd; stn 301, 8°12.4' N, 55°50.2' W, 2487–2500 m, 3 lv (holotype), 4 dd; R/V KNORR 35, stn 340, 38°14.4' N, 70°20.3' W–38°17.6' N, 70°22.8' W, 3264–3356 m, 10 lv (5 paratypes), 8 dd.

Etymology: Named after the shells' narrow, "thread-like" outline.

Distribution: Collected alive between 1518–3264 meters in the Western Atlantic Ocean from the North Blake Plateau and the Puerto Rico Trench.

Remarks: The thread-like aspect with sides almost parallel and length of shell differentiate this new species from other Atlantic and worldwide *Pulsellum* species. Maximum length 9.2 mm.

Genus *Striopulsellum* Scarabino, 1995

Remarks: As result of the present study, the genus *Striopulsellum* assembles six species and confirms its preference for bathyal to hadal depths worldwide. These are *Striopulsellum minimum* (Plate, 1908) (Lectotype ZMB/Moll-5972Sa), the type species, with circum-Antarctic distribution (3423–6179 m depth), also recorded from New Caledonia (Scarabino, 1995) and in the Vema Basin, Argentina, live at 3423–6179 m (Scarabino, 1979, and present paper) (Figures 13, 37, specimen and radula respectively), *Striopulsellum striatinum* (Henderson, 1920) (Syntypes USNM 108106, examined) described off Fernandina, Florida, USA, from 537 m, representing the shallowest record for the genus; *Striopulsellum galatheae* Knudsen, 1964, collected alive in the Sunda Trench at 6900–7000 m depth (Holotype ZMUC), and the three new species described herein: *Striopulsellum sandersi* new species, widely distributed in the north Atlantic ocean at 3264–5800 m depth; *Striopulsellum knorr* new species in the Puerto Rico Trench at 4429–4934 m depth; and *Striopulsellum atlantis* new species, from northeastern Brazil at 943–1007 m depth.

Striopulsellum sandersi new species (Figures 7–12, 36)

Description: Shell 7.2 mm long, translucent grey, regularly curved and slow tapering, arc located anterior to centre of shell. Longitudinally sculptured by 24 fine primary striae at apex and secondary ones that arise early and are doubled in number. Surface finely granulose. Apex oblique, dorsal side longer, circular in section, pre-apical callus thick. Walls of apical area alternate thinner and thicker sections, easily observed by transparency. Anterior aperture straight, circular in cross-section.

Radula (Specimen from R/V KNORR 35, stn 340): Rachidian teeth polygonal, anterior margin with three cusps, one central and two minor ones, lateral profile thicker at posterior border and thinner at anterior border, delimited by a cusp. Lateral teeth with five denticles between main cusps. Marginal teeth straight, with contact border large.

Measurements of Holotype: L 7.2, Max 0.5, Apd 0.1, Arc 0.4, Larc 4.

Type Material: Holotype (lv) MCZ 293944 and 5 paratypes: 3 (lv) MCZ 293945, 2 (lv) MNHN 24334.

Type Locality: North Blake Plateau, 40°42.6' N, 46°13.8' W, 4400 m, R/V CHAIN 106, stn 334.

Other Material Examined: R/V CHAIN 106, stn 334, 40°42.6' N, 46°13.8' W, 4400 m, 15 (holotype and 3 paratypes); R/V KNORR 35, stn 340, 38°14.4' N, 70°20.3' W, 3264–3356 m 3 lv; ABYPLAINE, stn CP 21, 42°57.7' N, 13°59.2' W - 42°58' N, 14°44.0' W, 5260 m, 1 lv; stn DS 04, 34°54' N, 21°26.10' W, 5160 m, 1 lv, 1 dd; stn DS 06, 32°03' N, 22°01' W, 5250 m, 1 lv; stn DS 10, 42°51' N, 15°55' W, 4270–4360, 3 dd; stn DS 11, 43°00' N, 14°05' W, 5260 m, 2 lv (paratypes). BIOGAS VI, stn 10-CB5, 55°43' N, 49°21' W, 3676 m, 1 lv; stn 19-CB8, 38°55, 46°47' W, 5320 m, 5 lv, 2 dd; stn 78, 46°31' N, 10°24' W, 4706 m, 1 lv; stn 79, 44°30' N, 10°27' W, 4715 m; BIOVEMA, stn 09, 11°36' N, 32°52' W, 5875 m 32 lv; stn CP 22, 44°42' N, 17°59' W, 1 lv; stn DS 04 34°54' N, 21°26' W, 5160 m, 10 lv; stn DS 06, 32°03' N, 22°01' W, 5250 m, 2 lv; 2 dd; stn DS 10, 11°33' N, 32°52' W, 5875 m, 3 lv; stn DS 11, 43°00' N, 14°05' W, 5260 m, 2 lv; NORATLANTE, 1969, stn 21, 38°28' N, 3°03' W, 5228–5240 m, 2 lv; stn DS 08, 52°10' N, 45°32' W, 4100–4120, 1 lv; stn DS 19, 38°55' N, 46°47' W, 5320, 2 lv.

Etymology: Named after the late Dr. Howard L. Sanders (WHOI), contemporary pioneer of deep-sea zoological research of the Atlantic Ocean, who hosted the senior author in his laboratory at Woods Hole, many years ago, and made available for study several of the specimens described in the present paper.

Distribution: Collected alive between 3264–5800 meters from the North Atlantic basin, Vema Trench and the Gulf of Gascony.

Remarks: Compared to the other two new species described here, *Striopulsellum sandersi* new species is more regularly curved than *S. knorr* new species and *S. atlantis* new species, has the apex oblique and it is specially identified by the characteristic structure of the wall on the apical area. Shells frequently present breakages and repairs. Maximum length 11.3 mm.

***Striopulsellum knorr* new species**

(Figures 17, 34–35)

Description: Shell 5.5 mm long, translucent grey, slightly curved and slow tapering. Longitudinally sculptured by 34 fine but well-defined primary striae, secondary ones appearing on posterior quart, doubling in number. Apex straight, circular in cross-section, apical callus thick, lumen circular. Mouth straight, circular in section.

Radula (Holotype): Rachidian teeth polygonal, anterior margin with single cusp. Lateral teeth with four

denticles between main cusps. Marginal teeth slightly curved.

Measurements of Holotype: L 5.5, Max 0.6, Apd 0.2, Arc 0.3, Larc 2.2.

Type Material: Holotype (dd) MCZ 293947 and 6 paratypes (2 lv, 1 dd) MCZ 293948, (3 dd) MCZ 293949.

Type Locality: Puerto Rico Trench, 11°2.2'N, 55°4.8'W, 4417–4429 m (R/V KNORR 25, stn 288).

Material Examined: Puerto Rico Trench, R/V KNORR 25, stn 287, 13°15.8'N, 54°52.2'W, 4934–4980 m (3 paratypes, dd); stn 288, 11°02.2'N, 55°4.8'W, 4417–4429 m (holotype and 3 paratypes, 2 lv, 1 dd).

Etymology: Named (name in apposition) after the R/V KNORR (WHOI).

Distribution: Puerto Rico Trench, collected alive in 4429–4934 m.

Remarks: When compared to the other congeners, *Striopulsellum knorr* is almost straight, its apical callus is thicker, and the striae are less evident.

***Striopulsellum atlantis* new species**

(Figures 7, 14–15, 32–33)

Description: Shell 6 mm, slender, slightly curved, fragile, translucent grey. Apical area smooth, with 72 fine striae, appearing early and covering the remainder of shell. Spaces between striae convex and surface roughly granulose. Apex simple, preapical callus thin.

Radula (Holotype): Rachidian teeth polygonal, anterior border irregular. Head of lateral teeth with four denticles between the three main cusps, in number of two in the internal side and one more pointed on external side of teeth head. Marginal teeth slightly curved, thicker at contact points with laterals.

Measurements of Holotype: L 6, Max 0.75, Apd 0.3, Arc 0.2, Larc 3.1.

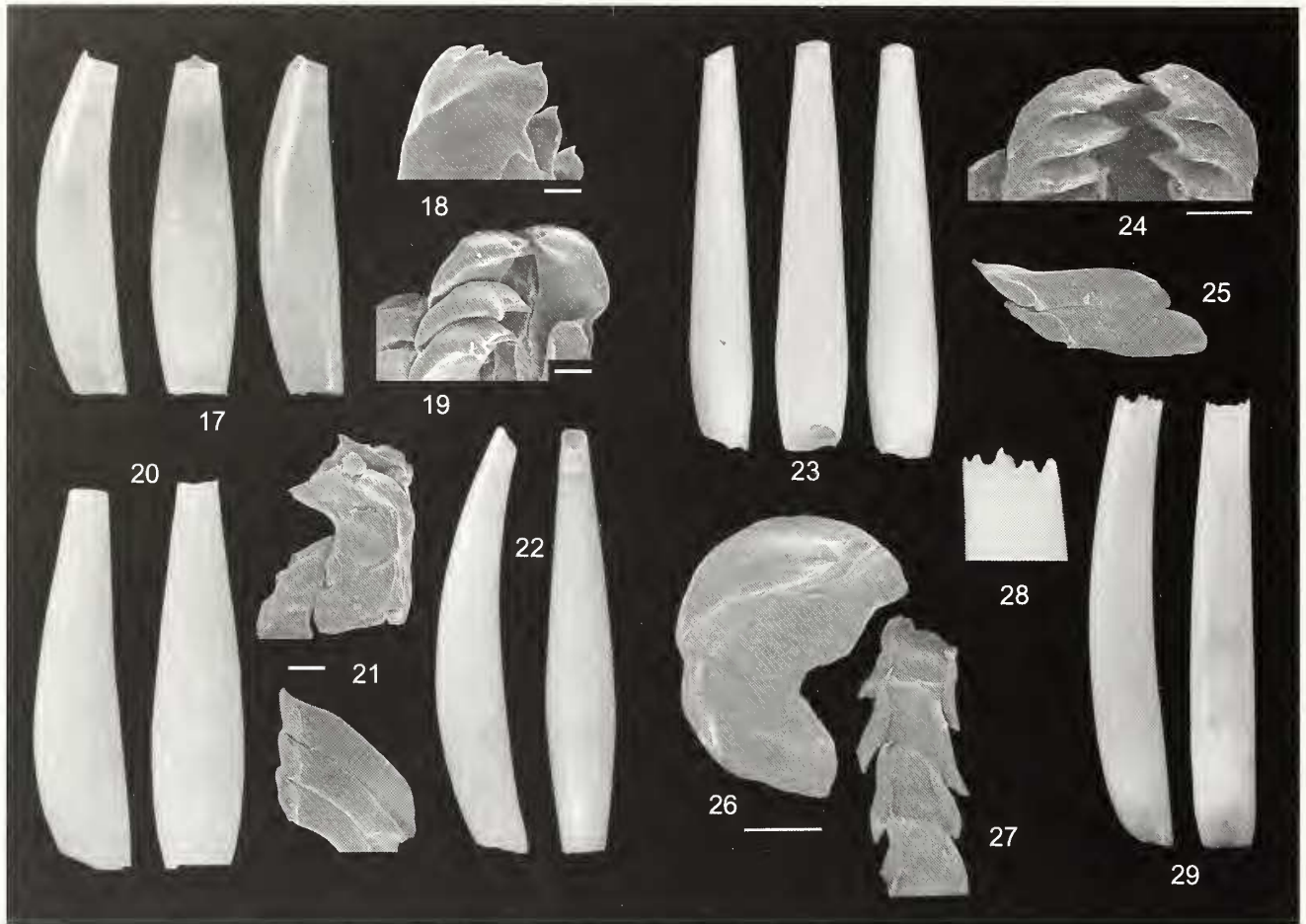
Type Material: Holotype (lv): MCZ 293950; paratypes (2 lv) MCZ 293951.

Type Locality: Off Pernambuco, Brazil, 7°58' S, 34°17' W, 943–1007 m (R/V ATLANTIS-II-31-167).

Other Material Examined: Off Pernambuco, Brazil, R/V ATLANTIS II-31-167, 7°58' S - 34°17' W, 943–1007 m, 3 lv.

Etymology: Named (name in apposition) after the R/V ATLANTIS II (WHOI).

Distribution: Known only from the type locality. Collected alive at 943–1007 m.



Figures 17–29. Species of *Cadulus*, *Gadila*, *Chistikovia*, and *Siphonodentalium*. **17–19.** *Cadulus unilobatus* new species, holotype (4 mm), Gulf of Gascony, 47°36.1' N, 8°40.5' W, 2360 m, BIOGAS V stn DS 65. **17.** *Cadulus unilobatus* new species, holotype (4 mm), Gulf of Gascony, 47°36.1' N, 8°40.5' W, 2360 m, BIOGAS V stn DS 65, lateral, dorsal and ventral views. **18.** *Cadulus unilobatus* new species, paratype, radula, details of the head of lateral teeth, internal view (bar 10 μ m). **19.** Radula, external view of lateral, rachidian, and head or marginal teeth. Scale bar = 10 μ m. **20, 21.** *Gadila cretea* new species, holotype (5.5 mm), off Fernando de Noronha, Brazil, 00°3' S, 27°48' W, 3730–3787 m, R/V ATLANTIS II-31 stn 155, lateral and dorsal views. **20.** *Gadila cretea* new species, radula, Gulf of Gascony, 47°27.30' N, 9°39.9' W, 4354 m, INCAL, stn WS10, internal view of lateral and rachidian teeth. Scale bar = 10 μ m. **21.** *Gadila cretea* new species, radula, same locality as of specimen in Figure 20, internal view of marginal teeth. Scale bar = 10 μ m. **22.** *Gadila celtica* new species, holotype (10.6 mm), Gulf of Gascony, 47°32.5' N, 9°04.1' W, 2813 m, BIOGAS II stn DS 31, lateral and dorsal views. **23–25.** *Chistikovia atlantica* new species, holotype (16.9 mm), North Blake Plateau, 40°42.6' N, 46°13.8' W, 4400 m, R/V CHAIN 106 stn 334. **23.** Lateral, ventral and dorsal views of the shell. **24.** Radula, external view of lateral teeth heads and rachidian teeth. **25.** Internal view of marginal teeth. **26–29.** *Siphonodentalium coronatum* new species. **26.** Paratype, radula, internal view of lateral tooth. **27.** Rachidian teeth, internal view. Scale bar: 100 μ m. **28.** Details of shell apex. **29.** Holotype (16.1 mm), North Blake Plateau 40°42.6' N, 46°13.8' W, 4400 m R/V CHAIN 106, stn 334, lateral and dorsal views.

Remarks: *Striopulsellum atlantis* differs from its congeners by the absence of sculpture at apical sector and less noticeable striae.

Subfamily Gadilinae Stoliczka, 1868

Genus *Cadulus* Philippi, 1844

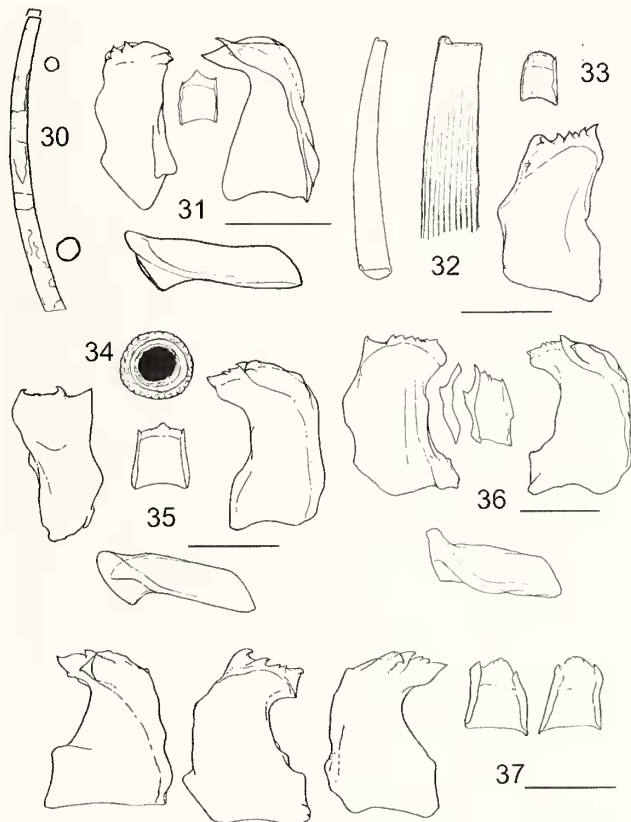
Cadulus unilobatus new species

(Figure 17–19)

Description: Shell 4 mm long, translucent white, maximum diameter at anterior third of shell. In lateral view,

ventral side is regularly curved to apex, whereas dorsal side shows very slightly concave and convex alternating lines. In frontal view, sides are almost straight, from maximum diameter to apex and to mouth. Growth lines well-defined, straight. Apex wide, slightly dorsoventrally compressed, with small, rounded edge lobe on ventral side. Preapical callus thick, lumen dorsoventrally oval. Anterior aperture straight, slightly dorsoventrally compressed.

Radula (Paratype): Rachidian teeth polygonal, anterior border with small medial pointed process. Lateral teeth strong, surface of head irregular, with three main cusps, two of which are located on internal area and third



Figures 30–37. Species of *Pulsellum* and *Striopulsellum*. **30–31.** *Pulsellum filiforme* new species. **30.** Lateral view and apical and oral profiles. **31.** Radula of holotype, left, lateral teeth, internal face; right, lateral faces; center, rachidian tooth; below, marginal teeth. Scale bar = 100 μ m. **32–33.** *Striopulsellum atlantis* new species, holotype (6 mm), off Pernambuco, Brazil, 7°58' S, 34°17' W, 943–1007 m, R/V ATLANTIS-II-31-167], lateral view and details of apical area. **33.** Holotype, radula, above, rachidian tooth; below, lateral tooth, internal view. Scale bar = 100 μ m. **34–35.** *Striopulsellum knorr* new species, holotype (5.5 mm), Puerto Rico Trench, 11°2.2' N, 55°4.8' W, 4417–4429 m, R/V KNORR 35, stn 340, left, lateral tooth, external view; right, lateral tooth; center, internal view; below, marginal tooth. Scale bar = 100 μ m. **36.** *Striopulsellum sandersi* new species, radula, R/V KNORR 35, stn 340, left, lateral tooth, external view; right, lateral tooth; center, internal view; rachidian, lateral and internal views; below, marginal tooth (bar: 100 μ m). **37.** *Striopulsellum minimum* (Plate, 1908), radula, left, views of lateral teeth; right, internal views of rachidian teeth.

cusps wide and small, external pointed cusp. Between cusps, four denticles of different sizes, placed at different angles between cusps. Marginal teeth slightly curved with thicker contact point with laterals.

Measurements of Holotype: L 4, Max 1/0.9, Dmax 1.2, Oap 0.66/0.6, Apd 0.4/0.35, Arc 0.14, Larc 1.5.

Type Material: Holotype (lv) MNHN 24335 and 2 paratypes (lv) MNHN 24336.

Type Locality: Gulf of Gascony, 47°36.1' N, 8°40.5' W, 2360 m (BIOGAS V stn DS 65).

Other Material Examined: BIOGAS V, stn DS 65, 47°36.1' N, 8°40.5' W, 2360 m, 10 lv (including holotype and 2 paratypes), 3 dd.

Etymology: Only one lobe, to highlight the apical feature.

Distribution: Known only from the type locality, collected alive in 2360 m depth.

Remarks: Relative location of the maximum diameter and the ventral apical lobe distinguishes *Cadulus unilobatus* from other congeners reported to the area such as *C. artatus* Locard, 1897 (holotype not located), *C. gracilis* Jeffreys, 1877 (holotype USNM 175853, examined), *C. jeffreysi* (Monterosato, 1875) (type material not located), *C. propinquus* G. O. Sars, 1878 (syntypes ZMO 26071–72), and *C. subfusiformis* M. Sars, 1865 (syntypes SMNH 4626). Other species presenting similar apical structure to *Cadulus unilobatus* are *C. teliger* Finlay, 1926 (Tertiary of New Zealand) from New Zealand (holotype AIM; paratypes ANSP 232249; DMNH 22370, examined), *C. vincentianus* Cotton and Godfrey, 1940, from the eastern Australia (Holotype, SAM D13730), and an undescribed species from the Philippines.

Genus *Cadila* Gray, 1847

Cadila cretea new species

(Figure 20–21)

Description: Shell 5.5 mm long, opaque chalky-white, fragile. Maximum diameter on anterior third. Dorsal side almost straight, ventral evenly convex on anterior three-fourths of shell, straight to apex. In dorsal view, sides present outline similar to ventral. Apex large, simple, circular in section, callus thick. Oral aperture oblique, slightly compressed laterally. Growth lines oblique.

Radula (INCAL: stn DS16, stn WS10): Rachidian teeth, with large sides and pointed medial cusp. Lateral teeth with two pointed processes on internal face and another on outer side, space in between with 8 denticles, external face of the head irregular. Marginal teeth slightly curved, keeled.

Measurements of Holotype: L 5.5, Dmax 1.6, Oap 0.7, Apd, 0.5. Arc 0.1, Larc 2.3.

Type Material: Holotype (lv) MCZ 293933 and 4 paratypes: 2 (lv), MCZ 293935, 193936; 2 (lv) MNHN 24337.

Type Locality: Off Fernando de Noronha, Brazil, 00°3' S, 27°48' W, in 3730–3787 m (R/V ATLANTIS II-31 stn 155).

Material Examined: R/V ATLANTIS II-31, stn 155, 0°3' S, 27°48' W, 3730–3787 m, 6 lv (holotype and 5 paratypes); BIAÇORES: stn 126, 39°19.5' N, 33°47.0' W, 3360 m, 4 dd; R/V KNORR 35, stn 340, 2 lv; 39°19.5' N, 33°47' W, 3360 m, 1 lv; R/V CHAIN 106, stn 334, 40°42.6' N, 46°13.8' W, 4400 m, 1 lv (paratype); stn 234, 38°14.4' N, 70°20.3' W–38°17.6' N, 70°22.8' W, 3264–3356 m 1 lv (paratype); INCAL, stn DS16, 47°29.8' N, 9°33.4' W, 4268 m, 2 lv, 1 dd; stn WS09, 47°28.80' N, 9°34' W, 4277 m, 1 lv 2 dd; stn WS10, 47°27.30' N, 9°39.9' W, 4354 m, 3 lv, 1 dd; stn DS15, 47°33.40' N, 9°39.10' W, 4211 m, 1 lv, 2 dd. BIOGAS IV, stn DS55, 47°34.9' N, 9°40.9' W, 4125 m, 16 lv (2 paratypes), 18 dd; BIOGAS V, stn DS66, 47°28.20' N, 9°00' W, 3480 m, 2 d; stn 67, 47°31' N, 9° 35' W, 4510 m, 1 lv; BIOGAS VI, stn DS75 47°28.1' N, 9°07.8' W, 3250 m, 1 lv 2 d; stn DS76, 47°34.8' N, 9°33.3' W, 4228 m, 17 lv, 2 dd; stn DS77 47°31.8' N, 9°34.6' W, 4240 m, 2 lv.

Etymology: From Latin *creteus*, chalk, referring to the surface texture on shells of this species.

Distribution: Live collected between 3264–4510 meters. Its range is amphi-Atlantic. In the Western Atlantic it is found in the Pernambuco Basin and Puerto Rico Trench, in Eastern Atlantic basins from the Gulf of Gascony to the Azores.

Remarks: According to its unusual shell outline, there is no similar species in the Atlantic Ocean to be compared with *G. cretea*. Maximum length 5.8 mm.

Gadila celtica new species

(Figure 22)

Description: Shell 10.6 mm long, gently curved, and tapering, polished white. Maximal diameter at anterior third. Ventral side regularly curved, dorsal side alternating concave and convex outline. Apex simple, clearly oblique, ventral side longer, slightly laterally compressed. Apical callus thin. Mouth slightly oblique, laterally compressed. Growth lines easily noticeable, also oblique. Radula unknown.

Measurements of Holotype: L 10.6, Dmax 1.7/1.9, Oap 1/1.1, Apd 0.5, Arc 0.33, Larc 4.1.

Type Material: Holotype (dd) MNHN 24338 and 3 paratypes (1 lv, 2 dd). MNHN 24339.

Type Locality: Celtic Sea, 47°32.5' N, 9°04.1' W, 2813 m (BIOGAS II, stn DS 31).

Material Examined: BIOGAS II, stn DS 31, 47°32.5' N, 9°04.1' W, 2813 m, 1 dd (holotype). BIOGAS III stn DS 38, 47°32.5' N, 8°35.8' W, 2138 m, 2 dd (paratypes); BIOGAS V, stn DS 65, 47°36.1' N, 8°40.5' W, 2360 m, 1 lv (paratype).

Etymology: Named after the Celtic Sea, general area of the type locality.

Distribution: Collected alive in 2360 meters, with dead shells found between 1913–2813 meters. A North Atlantic Ocean species known from the Northeastern Celtic Sea and the Gulf of Gascony.

Remarks: *Gadila celtica* can be compared to *G. miamiensis* (Henderson, 1920), from off Florida (USA) in 209 fms (382 m) (holotype USNM 314772, examined) and *G. bushii* (Dall, 1889) from Barbados in 100 fms (182 m) (lectotype MCZ 7745, examined). Individuals of both species are smaller than *G. celtica* and have a straight apex. *Gadila miamiensis* has the most similar outline, but is more curved and the oral profile is more oblique than *G. celtica*, and *G. bushii* clearly tapers faster and the apical area is narrower.

Family Wemersoniellidae Scarabino, 1986

Genus *Chistikovia* Scarabino, 1995

Chistikovia atlantica new species

(Figure 23–25)

Description: Shell 16.9 mm long, porcelain white, solid, almost straight and clearly dorsoventrally depressed. Maximum diameter near the oral aperture from where the shell tapers regularly to apex and mouth. Unsculptured, except for very oblique, conspicuous, and close-set growth lines. Apex wide, margin very oblique, dorsal side higher, callus thick. Mouth thin walled, oblique.

Radula (Holotype): Rachidian teeth polygonal with anterior margin simple. Lateral teeth strong, with a sharp pointed primary cusp with irregular grooves on the outer part of the head. Marginal teeth almost straight, pointed at inner margin.

Measurements of Holotype: L 16.9, Max 2.5/2.9, Dmax 4.4, Oap, 1.8/1.5, Apd 1-1.3.

Type Material: Holotype (lv) MCZ 293927 and 5 paratypes (1 lv, 4 dd); 3 MNHN 24340 (1 lv, 2 dd); 1 ZMUC (dd); 1 (dd) MOM 291146.

Type Locality: North Blake Plateau, 40°42.6' N, 46°13.8' W, 4400 m (R/V CHAIN 106, stn 334).

Material Examined: R/V CHAIN 106, stn 334, 40°42.6' N, 46°13.8' W, 4400 m (1 lv, holotype); BIOGAS III: stn CV 23, 47°32.7' N, 8°34.2' W, 2034 m, 1 dd; BIOGAS IV, stn DS 55, 47°34.9' N, 9°40.9' W, 4125 m, 1 lv; BIOGAS V, stn DS 66, 47°28.2' N, 9°00' W, 3480 m, 2 lv, 1 dd; BIOGAS VI, stn DS 75, 47°28.1' N, 9°07.8' W, 3250 m, 1 dd; stn DS 76, 47°34.8' N, 9°33.3' W, 4228 m, 1 lv, (paratype) 1 dd; INCAL, stn DS 10, 50°12.7' N, 13°16.6' W, 2719 m, 1 dd

(paratype); stn DS 15, 47°33.4' N, 9°39.1' W, 4211 m, 1 dd (paratype); stn WS 07, 55°00.7' N, 12°31' W, 2884 m, 1 dd. NORATLANTE, stn 10 CB5, 55°43' N, 49°21' W, 3876 m, 1 dd; R/V PRINCESSE-ALICE II (1911), stn 2964, 46°17.30' N, 05°42' W, 4387 m, 1 dd (paratype); INCOLF (1895), stn 38, 59°12' N, 51°05' W, 3521 m, 1 dd (paratype).

Etymology: Relative to the Atlantic Ocean.

Distribution: Collected alive between 3250–4400 meters, dead shells found between 2034–4400 meters. A North Atlantic Ocean species found off the southwest and south coast of Greenland, high latitudes of the central and northeastern Atlantic, off Ireland and the Gulf of Gascony.

Remarks: The other species of this genus are *Chistikovia kermadecae* Scarabino, 1995 (the type species) from Kermadec Trench, New Zealand in 2470–4570 m (holotype ZMUC, 11.5 mm), and *Chistikovia earlessi* (Lamprell and Healy (1998), as *Gadila earlessi*) from northern Queensland, Australia, in 2710 m, (holotype QM MO40084, 19.2 mm). *Chistikovia atlantica* is similar to *C. earlessi*, the main difference being the location of the maximum diameter, clearly more anterior in the latter than in the new species. *Chistikovia kermadecae* has the ventral side slightly curved, not straight as in *C. atlantica* and *C. earlessi*, and, in addition, the apical structure is better defined.

Family Siphonodentaliidae Simroth, 1894

Genus *Siphonodentalium* M. Sars, 1859

Siphonodentalium coronatum new species
(Figure 26–29)

Description: Shell 16.1 mm long, slightly curved, brilliant white, fragile. Maximal diameter near oral aperture, gradually tapering to apex. Ventral side regularly convex, dorsal side regularly concave from maximum diameter to apex, almost straight to mouth. Apex notably large, crown-like, with 12 lobes, five each on dorsal and ventral sides and two lateral, higher and sharper due to deep latero-ventral notches. Oral aperture oblique, slightly dorsoventrally depressed.

Radula (Paratype, MNHN 24341): Rachidian teeth with one cusp on lateral sides and three smaller ones on anterior side, two of which ventrally placed and one centro-dorsally placed. Lateral teeth with large anterior third, curved, with two pointed processes on dorsal face and one smaller on one side and another on other side, with smooth intervening gap. Marginal teeth straight.

Measurements of Holotype: L 16.1, Max 2.5, Oap 2.0/1.9, Dmax 4.8, Apd 1.6, Arc 0.6, Larc 7.2.

Type Material: Holotype (lv) MCZ 293926 and 2 paratypes (lv) MNHN 24341.

Type Locality: North Blake Plateau, 40°42.6' N, 46°13.8' W, 4400 m (R/V CHAIN 106, stn 334).

Other Material Examined: R/V CHAIN 106, stn 334, 40°42.6' N, 46°13.8' W, 4400 m, (lv) holotype; BIOGAS II, stn DS 23, 46°32.8' N, 10°21' W, 4734 m, 1 lv (paratype); BIOGAS V, stn DS 69, 44°21.9' N, 4°52.4' W, 4510 m, 1 lv (paratype); stn DS 82, 44°25.4' N, 4°52.2' W, 4462 m, 1 lv; stn CP 19, 44°24.9' N, 4°51.3' W, 4434 m 1 lv; INCAL, stn WS 08, 47°30.5' N, 9°32.9' W, 4287 m, 1 dd.

Etymology: Specific epithet refers to the crown-like shape of the apex.

Distribution: Collected alive between 4510–4734 meters, dead shells from 4287 meters. A North Atlantic Ocean species found southwest of Ireland, the Gulf of Gascony and off Portugal.

Remarks: Three other species of *Siphonodentalium* are cited for the northeastern Atlantic: *Siphonodentalium lobatum* (Sowerby, 1860) (syntypes NHMUK 1951.2.14.4–5, examined), *Siphonodentalium laubieri* Bouchet and Warén, 1979 (holotype and paratypes at MNHN, examined), and *Siphonodentalium spectabilis* (Verrill, 1885) (lectotype USNM 37935, examined). The first species is more curved and tapering than the new species, and *S. laubieri* has only four lobes and notches. *Siphonodentalium laubieri* is known only from the Norwegian Sea and the Laptev Sea in 2212–2502 m depth (Sahlmann et al., 2009), whereas *S. lobatum* has a large geographic and bathymetric distribution in the northern Atlantic from off British Islands to Spitzbergen, Arctic Sea and Barents Sea in 38–3100 m depth (Ivanov and Zarubina, 2004). *Siphonodentalium spectabilis* (Verrill, 1885), occurs in the northwestern Atlantic at 2780 m depth and has ampho-Atlantic distribution; it is much more tapering than the other species and have distinct arrangement and size of apical lobes.

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